

Structure and Reproduction of *Cottoniella hawaiiensis* n. sp. (Rhodophyta)¹

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WHILE SORTING over fine red algae washed onto the beach at Kailua, Oahu, Hawaiian Islands, the junior author discovered an alga which appears to be representative of a previously undescribed specific taxon to be placed in the genus *Cottoniella* for reason of its obvious similarities to *Cottoniella arcuata* Boergesen, the type of that genus. Accordingly, this newly found material is described here as:

Cottoniella hawaiiensis n. sp.

Figs. 1-9

Thalli 2 cm. longi, ramis sterilibus polystichis ad 130 μ diametro et a 4 cellulis pericentralibus cinctis, cellula apicale 10-12 μ diametro in serie segmentis discoideis transversalibus partita, segmentis deinde 4 cellulis pericentralibus ferrentibus, ramis endogenis a apicibus cellulis centralibus productis et eis stichidiis tetrasporangialibus vel ramis vegetalibus a ramo parenti simulantibus formantibus, ramis haplostichis determinatis ex angula ventrali anteriori cellulae lateralarum pericentralium ferrentibus, stichidiis tetrasporangialibus jugum sporangiarum tetrahedro-partitarum ferrentibus, loculis sporangialibus ad 74 μ longa et ad 60 μ diametro.

The specimens were pale pink and, when disengaged from the other polysiphonous algae in which they were floating entangled,

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could be separated into lax unilateral branch systems up to about 2 centimeters tall (Fig. 1). The principle branches are up to 130 microns in diameter. The species is known only from the type collection (M. Doty No. 13,582) made November 13, 1955 by the junior author. The type is deposited in the Bernice P. Bishop Museum with isotypes in the herbaria of the senior author, the New York Botanical Garden, the University of California (UCM-132664), and the University of Adelaide (21,100).

It is to be noted (Figs. 2, 6) that the arching of the branches begins distad of the appearance of branch initials in *C. hawaiiensis* and appears to be correlated with elongations of the first pericentral cell produced. This characteristic of the branches is much like that figured by Silva and Cleary (1954: 252, fig. 15) for *Platysiphonia parva*.

The bases of the apical cells of the young endogenous branches, which are the only branches that become corticated, are about 10 microns in diameter. The bases of the apical cells of the principle axes are often 12 microns in diameter.

The discoidal segments cut off from the apical cells of the main branches elongate until they are at least one-third of their diameter in length (Figs. 2, 5, 6). They then produce abaxially first a dorsal pericentral cell (Figs. 6, 7). At this time there are usually two discoid cells between that which bear this first pericentral cell and the apical cell. It appears that the pericentral cells to the right and left of the dorsal first pericentral cell are the next

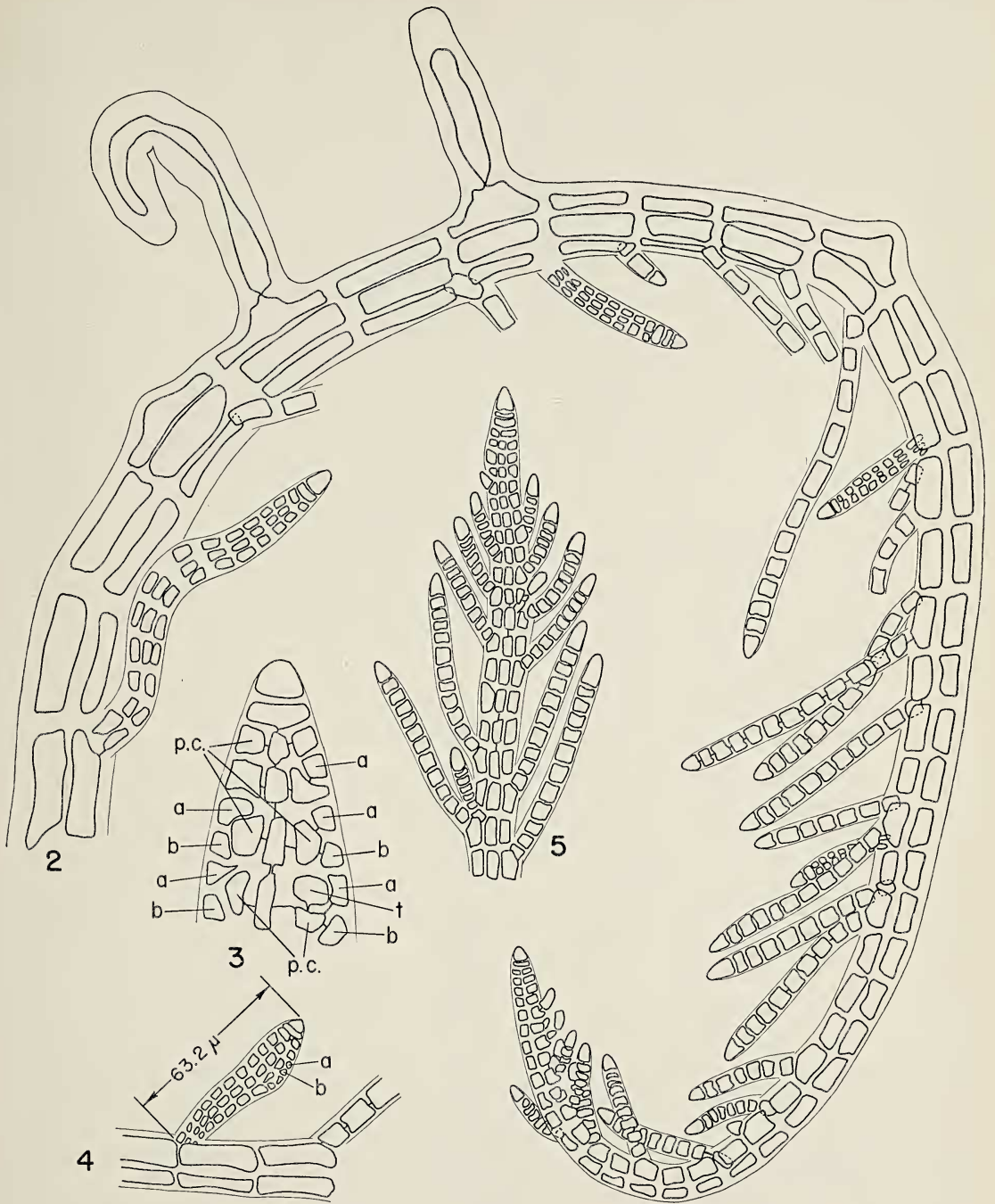


FIG. 1. Sketch of a major branch system showing branch curvature, positions of branches of different kinds, and relative diameters. The largest of the four major branches shown was about 0.5 cm. in length.

to be produced. The fourth pericentral cell is cut off opposite the first and from about the fifth segment removed from the apical cell. Collections of *Cottoniella arcuata* made by A. J. Bernatowicz in Bermuda (53-380 and 53-96) show a similar sequence of pericentral cell development. This is in contrast to what Boergesen (1930: 146) says is true of his *C. fusiformis* from the Canary Islands.

The endogenous branches arise (Figs. 5, 7) from the anterior ventral surfaces of segments in front of or at the corner of the ventral peri-

central cells. An endogenous branch on a segment is somewhat parallel to any exogenous branch that may be on the same segment. Endogenous vegetative branches develop entirely like the parent axis and (as in *C. arcuata*) curve toward the parent axis in their development. The lateral pericentral cells on vegetative branches were seen in no case to divide other than in the production of exogenous branches. In more basal parts of the thalli, the longest branches of this sort are up to 675 microns long.



FIGS. 2-5. (2) Cellular detail of one indeterminate branch to show relationships of size and position of ultimate branch kinds and their origins in part. (3) Ventral view of tetrasporangial stichidium apex. Neither dorsal nor ventral pericentral cells shown. (4) Young tetrasporangial stichidium. (5) Cellular detail of indeterminate branch apex from ventral view. Neither dorsal nor ventral pericentral cells shown.

Exogenous monosiphonous branches appear on about the sixth or seventh segment removed from the apical cell (Figs. 2, 5). Boergesen's figure (1919: 336, fig. 335) shows the monosiphonous branches as arising at about the tenth to fourteenth segment in his species, *C. arcuata*. With Bermuda materials of *C. arcuata*, provided by A. J. Bernatowicz, we have been able to confirm this observation. Boergesen also describes and figures the monosiphonous branches as arising on the convex side of the branch endogenously. In the Bernatowicz collections cited, the tips curve and the branches appear on the convex side, the branches then become reflexed or curved in the other direction so that at maturity the branches do indeed protrude from the concave surface.

These uncorticated exogenous branches are about 20 microns in diameter and, while the basal cell hardly becomes more than twice its diameter in length, the other proximal cells of these ultimately 14- to 16-celled branches become up to 5 times as long as broad (Figs. 1, 2). The cells of the distal portion of these more or less determinate branches become progressively shorter distally until they are, just beneath the apical cell, discoid in immature branchlets with hemispherical apical cells, or elongated and tapered toward the slender conical apical cell of a mature branchlet.

The basal cells of the uncorticated exogenous branches are attached by their primary pit to the anterior-ventral corner of a lateral pericentral cell. They occur alternately on the right and left lateral pericentral cells of successive segments (Fig. 5). Secondary pits are formed in abundance between this basal cell and at least the lateral pericentral cell in the next anterior segment (Fig. 8). At least one of these secondary pits may be unusually large (see Fig. 8).

The older exogenous branches apparently drop off as the axes develop. Boergesen (1919: 147, fig. b) notes that exogenous branching was very rare in *C. fusiformis*. He illustrates them, however, as exogenous at

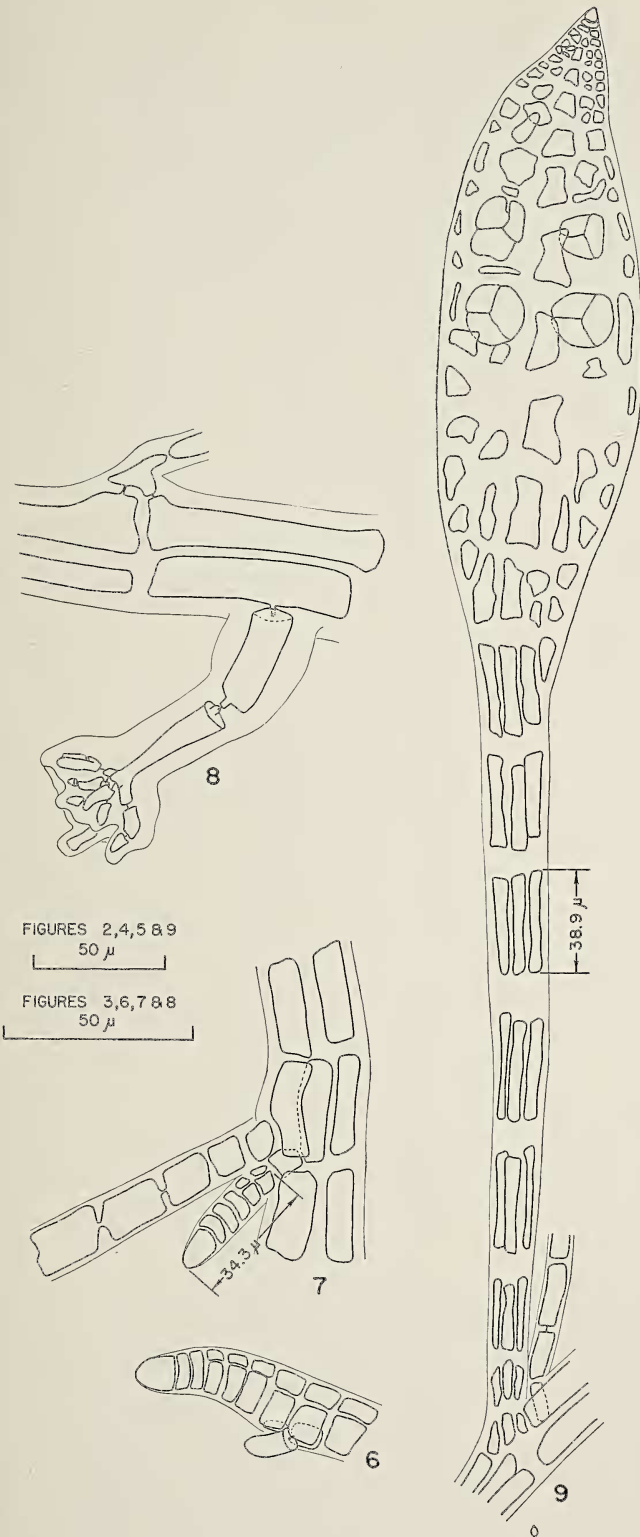
least once. According to Papenfuss (1944: 207), of the Delesseriaceae, only *Taenioma* and *Caloglossa* have exogenous branches. On this point our organism seems to be more rhodomeleaceous than delesseriaceous.

The rhizoids are exogenous and appear several segments posterior to the level at which endogenous branches appear (Figs. 1, 2, 8). They do not appear until after the other branches have appeared. They appear only from dorsal pericentral cells in our material. Sometimes a segment will bear one of each of the three types of branch. The rhizoids (Figs. 2, 8) become separated from the parent pericentral cell (Fig. 2) at an early age and may become a few cells in length (Fig. 8). There is a tendency for the rhizoids to be curved. Their tips become a disc of rows of small, crowded cells, connected by pits, that in some instances seem to have arisen by sympodial development (Fig. 8). In at least one case this pad was stuck to the *Polysiphonia* with which it was found entangled.

The tetrasporangial stichidia arise endogenously in the same positions as do endogenous vegetative branches and appear to take their place. The discoid segments cut off by the apical cell of the stichidium usually elongate to about one third of their diameter before cutting off a pericentral cell (Figs. 3, 4, 9). This usually occurs at the level of the first or second discoid cell. The first pericentral cell appears to be either dorsal or ventral; each situation was found with about equal frequency. Only a few rather disarranged branches were available for study of this point, however. The other three pericentral cells appear very rapidly and are usually present on the second or third discoid central cell segment.

The younger pairs of tetrasporangia arise towards the apex of the stichidium (Figs. 3, 9). The lumen of the tetrasporangium is radially elongated at least to a length of 60 microns at maturity, while the diameter parallel to the stichidial axis is about 47 microns. The tetraspores (Fig. 9) are tetrahedrally arranged.

The lateral pericentral cells each serve as



FIGS. 6-9. (6) Indeterminate branch apex from lateral view. Central cells not shown beyond third cell below apex, ventral pericentral cell not shown in lowest segment. (7) Cellular details of young indeterminate branch. (8) Cellular details of mature rhizoid and of an exogenous determinate branch basal cell. (9) Outline of mature tetrasporangial stichidium which had shed the contents of two sporangia.

tetrasporangial mother cells (Fig. 3*pc*). They produce two "cover" cells (*a* and *b* in Figs. 3, 4) (apical and basal), the tetrasporangium (Fig. 3*t*), and finally a third cover cell somewhat basally. The first two laterally produced cover cells curve around over the tetrasporangium. The third is produced ventrally and, likewise, grows over the surface of the sporangium. Thus the two pericentral cells (dorsal and ventral) and the three cover cells cut off by each of the two lateral pericentral cells at each side (i.e., 8 cells in all) make up the outer layers of each fertile mature stichidial segment.

DISCUSSION

Since "cortication" in our material consists, in sterile regions, only of pericentral cells, the opinion becomes critical as to whether or not there are "flanking cells" or "cover cells" present, cut off by the pericentral cell before the tetrasporangium. If there are flanking cells, one is inclined to consider *Cottoniella hawaiiensis* a member of the Delesseriaceae, accepting Papenfuss's (1944: 202) statement that, in that family, cover cells are cut off only after the tetrasporangium.

Certainly one "weakly-covering" cell is cut off *after* the tetrasporangium, and the lateral pericentral cells produce two cells lateral to themselves *before* the tetrasporangium is produced in the same way the flanking cells are produced in *Platysiphonia*.

The tetrasporangia are somewhat more covered over in *C. hawaiiensis*, and by a more complicated cover cell system, than in the case of *Taenioma* (Papenfuss, 1944: 195, figs. 4, 14, 199) or *Platysiphonia* (Silva and Cleary, 1954: e.g., 256, fig. 27), and other similarly simple members of the Ceramiales. However, the stichidial features are shown here for *Cottoniella* and for tetrasporangial areas of other genera, by various authors elsewhere, to be quite homologous in structure. Schotter has emphasized already (1951: 287) the similarity between the vegetative structure of *Cottoniella* and these two other genera. Especially are

Cottoniella and *Platysiphonia* similar in basic vegetative structure.

As regards the sequence of pericentral cell formation, it is interpreted as rhodomelaceous in all the *Cottoniella* material we have seen, following Naegeli's (1847, *vide* Schotter) early distinction of this family from the Delesseriaceae on this point. Boergesen's figures (1919: 147, fig. 59b, c) lead us to expect this in *C. fusiformis*, despite his statements to the contrary.

All in all it appears that *Cottoniella* is one of those simple algae that would some time ago have been placed in the Sarcomenioidae (Sarcomeniaceae of authors). The flattened four pericentral-celled nature of the stichidia of *C. hawaiiensis* bearing two tetrasporangia per segment bespeak of a delesseriaceous affinity for *Cottoniella*, and we are inclined to relegate it at present to that family but recognize its possible connecting-link nature between that family and the Rhodomelaceae.

SUMMARY

Study of tetrasporic *Cottoniella hawaiiensis*, a previously undescribed species from Hawaii, indicates placement of this genus among the Delesseriaceae on the basis of the mode of tetraspore production, or intermediately between that family and the Rhodomelaceae on the basis of weighting and interpretation of other features such as flanking cells, cover cells, apical cell development, and exogenous branches. The appearance of exogenous branches as a regular feature and the degree of development of the pericentral cell systems set the Hawaiian species apart from all others in this genus.

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